



# Identify the Maturity Level of Apples Using Fuzzy Logic Mamdani

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## ABSTRACT

Apples are one type of fruit that has properties including preventing disease, nourishing the body and being a menu when running a diet. This study aims to develop an identification system for the maturity level of apples using the mamdani fuzzy logic method. Fuzzy logic mamdani is a fairly good method of identification because the classes to be used have been predetermined. In this study, the apples used were Rome Beauty apples. The maturity level is based on the color which is divided into two, namely green raw and reddish yellow ripe. Data processing is done by preprocessing images such as resizing fruit directly. The accuracy of the dataset measured using this method results in an accuracy of 96%. In this study, an analysis of the input and output features needed by Mamdani's fuzzy logic was also carried out in classifying the maturity level of apples. The results showed that the input data could not be used effectively to classify the maturity level of apples due to the lack of input types used.

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## 1. INTRODUCTION

Apples are fruits that contain fruits such as high fiber, vitamin C, and various kinds of antioxidants. One apple is known to contain 95 calories. Most of it comes from the carbohydrate content in it. Although high in calories, apples are a fruit that is free of fat, sodium, and cholesterol. Apples also have 86 percent water content, therefore it will be very helpful for apple enthusiasts if a study is carried out that can help fruit enthusiasts. Whether this apple has reached a good level of maturity to eat through the color of its outer skin.

Each type of fruit has distinctive features to determine the degree of ripeness. one of them is skin color, acidity level of the fruit, fruit content, as in Apples, the classification of the maturity level of Apples is done manually by Apple growers. This certainly has the disadvantage that it requires more energy and accuracy of the level of maturity (in this study classifies whether the apple is Ripe, or Raw). Thus, a system is needed that can help to identify the maturity level of apples properly and efficiently.

Rome beauty apples are one of the most popular apples in Indonesia, including the type of Malang apple. The fruits are red-green. This red color is only found in parts exposed to sunlight, while green is found in parts that are not exposed to sunlight. The skin is coarsely porous and rather thick. The size of the fruit can reach 300 g. The flesh of the fruit is yellowish and slightly hard in texture. The taste is fresh, sweet-sour. The shape of the fruit is round to oblong. A tree in every 5 seasons is able to bear fruit as much as 15 kg. The tree itself is not very large, only 2-4 m (Samson, 1980). To find out the differences of each variety, observations were made on fruit development and physical testing. Pengujian fisik buah bagian luar pada buah meliputi ukuran diameter, tinggi, warna dasar, pola warna tambahan, warna penutup, dan bentuk buah (Didiek Kristianto, 2019).

Previous research conducted by Antonio Ciputra, De Rosal Ignatius Moses Setiadi, Eko Hari Rachmawanto, Ajib (2018) discussed the classification of the maturity level of manalagi apples with the naïve bayes algorithm and the extraction of digital image features. This study aims to determine the maturity level of manalagi apples and the level of accuracy of using the Naïve Bayes Algorithm in classifying the maturity level of manalagi apples. Research results trials that have been carried out on this study, it is proven that the proposed method can be used to calcify manalagi apples. However, the accuracy rate of each is less impressive, which is 63%.

Research conducted by Irvan Ramadan, Dahniel Syauqy, Rakhmadhany, Primananda (2021) discusses the Apple Maturity Detection System using the Naive Bayes Method based on the Embedded System. This study aims to detect the maturity level of apples using the Naive Bayes Method based on the Embedded System, based on images and it is hoped that this research can be used for the implementation of the Naive Bayes method in the apple maturity detection system runs almost as expected. Of the 10 test data, all data are in accordance with the original conditions. Therefore, test result data was obtained with an accuracy level of 100%.

Research conducted by Maghfirah, T.M. Johan, Zara Yunizar (2019) discusses the Identification of Papaya Maturity Stage Based on Color Using Fuzzy Method. For the recognition program, the Fuzzy method is used by extracting the matrix of each image and retrieving the Fuzzy value as unique from each set of images of various existing expressions. This application runs well even though the image crop tested is not perfect. From the trial data of 37 images as image tests against those in the training data, 62.1% success was obtained. Research conducted by Cinantya Paramita, Eko Hari Rachmawanto, Christy Atika Sari, De Rosal Ignatius Moses Setiadi (2019) discusses the Classification of Lime Against the Level of Fruit Maturity Based on Color Features Using K-Nearest Neighbor. Of the 25 test image data, the best accuracy was 92%.

Research conducted by Irwan Siswanto, Ema Utami, Suwanto Raharjo (2020) discusses the Classification of Fruit Maturity Level Based on Color and Texture Using the K-Nearest Neighbor and Nearest Mean Classifier (NMC) Methods. Based on the test results, it can be known that the K-Nearest Neighbor algorithm can classify the maturity level of any apple with a percentage level of truth of 73%.

Previous research conducted by Elok Faiqotul Himmah, Maura Widyarningsih, Maysaroh (2020) discussed the identification of oil palm fruit maturity based on RGB and HSV colors using the K-Means Clustering method. Based on the results of identifying the maturity of oil palm fruit with the K-means Clustering algorithm, the accuracy rate for test data was 79.16% and the accuracy rate for training data was 50%, so that the total accuracy rate of both was 64.58%.

Based on the explanation of the opinions of previous studies, the author conducted a study by implementing the fuzzy logic mamdani method to determine the maturity level of apples. This object uses Rome Beauty apples because of its many enthusiasts.

## 2. METHOD

Here are some steps carried out to identify the maturity level of Rome Beauty apples using Fuzzy Logic Mamdani. Figure 1 explains the research methodology, namely;

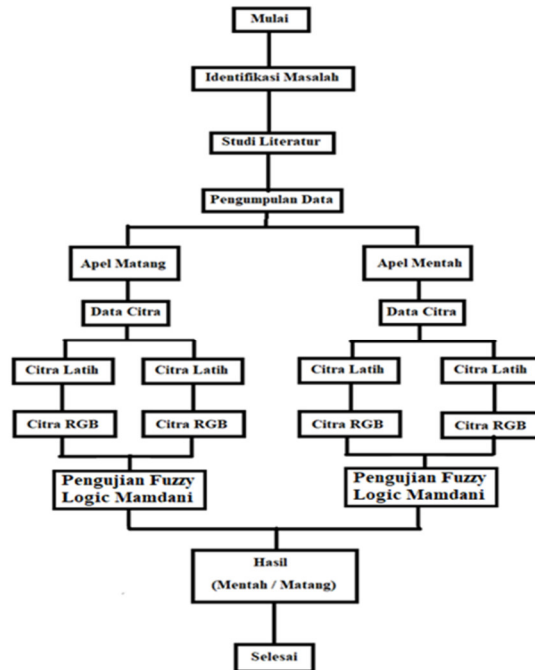


Figure 1. Rome Beauty Apple Identification Stages

**a. Identify the Problem**

At this stage, a collection of problems to be researched is carried out and determines the limits of the problems to be implemented. In this study, the application of scope was applied to Rome Beauty apples.

**b. Literature Study**

Exploration of information about the Fuzzy Logic Mamdani method and information related to research topics in various information media, such as data and formulations through journals, books, articles and the internet is carried out at this stage. This stage is aimed at collecting relevant reference research methodologies with a narrowed literature focus, so as to make new contributions and have a strong information base.

**c. Data Collection**

At this stage, data collection is carried out to be trained and tested. In this study, the data used is object data in the form of images of Rome Beauty apples taken from the Kaggle site. namely Apples will be classified into 2 types, namely Raw, Ripe taken from a total dataset of 140 images.

**d. Image Selection**

At this stage, the data will be selected to be taken photos with good image quality. Images that do not meet the quality will not be used. After the image has been selected, it will be saved in a folder based on its type.

**e. Test and Train Data Grouping**

Researchers will divide the data that has been collected into two, namely test data (data used for the testing process) and test data (data used for the testing process).

**f. Data Processing Methods**

This research data processing method is carried out in several stages. The stages carried out are as follows:

- a. Fuzzification and Fuzzy Input Limit Determination

This study has two input membership functions, namely the input function of large membership of green color values on apples, the input function of large membership of red color values on fruits.

b. Fuzzification and Fuzzy Output Limit Determination

This research has an Output membership function, namely the quality of the maturity level of apples.

g. **Analysis of Results**

The analysis process will be carried out to determine the accuracy of the success of the program in identifying human facial skin types based on their texture.

h. **Evaluation of the Basic Rules**

After the author determines the membership function, the basic rule is twenty-seven, which is obtained from the number of inputs in the power with the number of membership functions with each input, the number of inputs = 2 and the number of memberships of each input = 3, so  $3^2=9$ .

### 3. RESULTS AND DISCUSSION

In accordance with the formulation of the problem in chapter I, what will be discussed in this chapter is how the percentage of green color values on apples, and the percentage of red values on apples are needed to detect the maturity level of apples fuzzy inference system mamdani method.

#### A. Data Analysis

In making this system is divided into 2 parts. The first part is the process of making fuzzy machines, which is applying fuzzy rules based on data obtained from research. The second part is the process of visualizing fuzzy output. The first part is to find the output value of the fuzzy process using the mamdani method of several input and output variables. For the selection of quality apples, some beauty consists of two input variables and one output variable including:

Variable input is a data that will be processed in determining the level of maturity of apples, namely: Green Color Value and Red Color Value. The variable output is the output of the results obtained is the Level of Maturity.

#### B. Formation of fuzzy sets (fuzzyfication)

The fuzzy set consists of 3 input variables, 1 output variable and each variable has a different set including:

Table 1. Formation of Fuzzy Sets

Function	Variable Name	Fuzzy set name	Range
Input	Green	Little, medium, Many	0,255
	Red	Little, medium, Many	0,255
Output	Quality	Raw, Cooked	1-10

After determining the range, then determine the dominant value in each variable to be processed.

#### Green Variable

This variable is to determine what percentage of green is in the image of the fuji apple. This variety is very easy to find out if this fruit is raw Variable size can be seen in table 2.

Table 2. Green Variable

Variable	Set Name	Range
Green	Little	0-80
	Medium	80-90
	Many	90-255

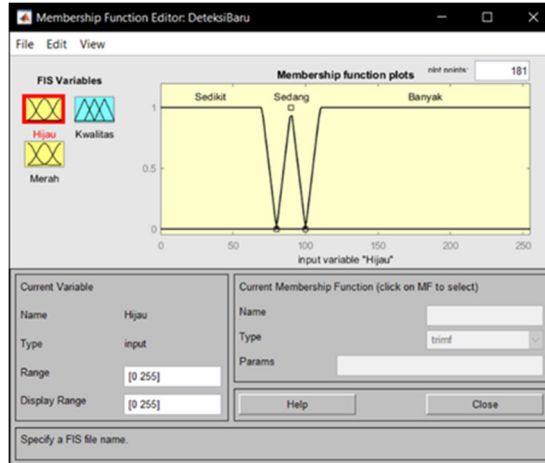


Figure 2. Green Variety Graph

**Red Variable**

This variable is to determine what percentage of red is in the image of the fuji apple. This variety is very easy to tell if this fruit is ripe. The size variable can be seen in table 3.

Table 3. Red Variable

Variable	Set Name	Range
Red	Little	0-70
	Medium	70-90
	Many	90-100

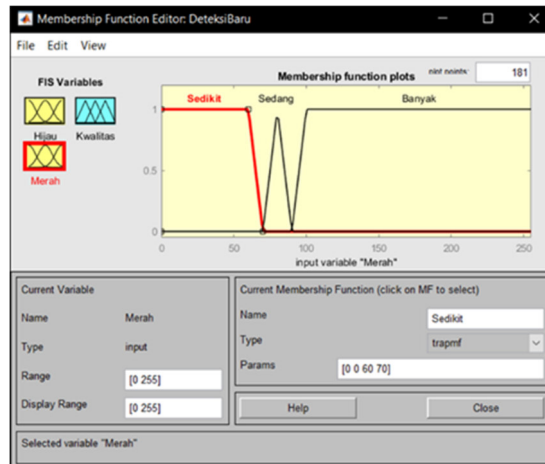


Figure 2. Red Variety Chart

**C. Determination of Rules of Each Input and Output Variable**

Fuzzy logic works based on rules to map inputs and outputs, which are done under conditions and actions. The form of conditions and actions can also be called IF-THEN or rules with the if-then format:

Table 4. Fuzzy Basic Rules Determination

No	Rules
R1	If (Green is Little) and (Red is Little) then (Quality is Mature)
R2	If (Green is Little) and (Red is Medium) then (Quality is Mature)
R3	If (Green is Little) and (Red is Many) then (Quality is Mature)
R4	If (Green is Medium) and (Red is Little) then (Quality is Mature)
R5	If (Green is Medium) and (Red is Medium) then (Quality is Mature)
R6	If (Green is Medium) and (Red is Many) then (Quality is Mature)
R7	If (Green is Many) and (Red is Little) then (Quality is Raw)
R8	If (Green is Many) and (Red is Medium) then (Quality is Raw)
R9	If (Green is Many) and (Red is Many) then (Quality is Raw)

#### 4. CONCLUSION

Based on research that has been carried out simulations with fuzzy mamdani. From the existing data produced a total of 96 correct data from 100 test data that the author has done. So that results in a percentage of 96%. The development of this simulation is even more complete, not only for the type of Fuji apple, but for all other types of apples such as green apples, red apples and the development of this simulation is made into an online-based fruit quality check.

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